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Improved Backpressure Regulator

Cross Reference to Related Applications

The present application is a regular application which claims priority from U.S. Provisional Patent Application 60/425,820, filed November 13, 2002, as well as from US Provisional Patent Application, Serial No. __________, entitled "Locally Powered Water Distillation System," filed November 10, 2003, all of which applications are incorporated herein by reference.

Technical Field

The present invention is directed to the field of pressure regulation, and may be especially relevant to fields that utilize a valve for controlling the pressure of gases in pressurized conduits.

Background Art

Backpressure regulators are essential to maintaining the safe and optimal operation of processes conducted under pressure. For example, in a vapor compression distillation system utilized to purify brackish or sea water into drinking water, excess system pressure from start-up volatile components, or created from compressors running off-specification, may constitute a danger to operators if such pressure is not relieved in a safe manner. As well, volatile components present in feed streams at start-up may present contaminants that interfere with proper operation of the system. Backpressure regulators may serve to relieve excess pressure, and to return an operating system to a desired operating pressure.

Some backpressure regulators utilize a spring-biased obstruction blocking a relief port in a pressurized conduit, the obstruction separating from the port when the internal pressure in the conduit exceeds a given set point. Such spring valves are troublesome since they require constant maintenance and recalibration by the valve user due to the changing spring constant value with aging and environmental conditions. The spring valves also

require individual, initial calibration due to the variation in spring constant from spring to spring.

The prior art devices may also utilize a weighted ball design that is direct acting, meaning the ball applies a force directly on the port. The downside of direct action is that either the weight required is large or the orifice is too small to enable rapid venting when the valve is open. As well, former weighted ball designs completely seal the port during system start-up, allowing the build up of volatile gasses that act as insulators to heat exchange and suppressors of boiling by inhibiting condensation against the heat exchange surface. Also, adjustment of the set point of the valves depends upon tailoring the weighted ball specifically to a particular application. Finally, many of the prior art devices are directed toward safety relief valves that simply act to relieve a dangerous system pressure condition; such devices do not allow quick restoration of the system to a normal pressure operating condition.

Summary of the Invention

One embodiment of the invention is directed to a backpressure regulator. The backpressure regulator includes a hinged arm having a closed position; and a movable stop shaped to cover a port connected to a pressurized conduit, the stop being held by a retainer attached to the arm, and the stop being positioned adjacent to the port when the arm is in the closed position; wherein the arm is away from the closed position when the pressure in the conduit exceeds a set point, and the arm is in the closed position when the pressure in the conduit is less than the set point.

In another embodiment of the invention, the backpressure regulator may include a counter mass adjustably attached to the arm, and the counter mass may be configured so that changing the counter mass position with respect to the arm changes the set point. The counter mass may be adjustably attached such that the lowest set point is substantially less than or equal to 10 psig, or such that the highest set point is substantially greater than or equal to 17 psig.

In a related embodiment of the invention, a backpressure regulator may further include a specifically designed leak vent at least when the arm is in the closed position.

In another related embodiment, the movable stop of a backpressure regulator is substantially ball-shaped.

Other embodiments of the invention utilize the backpressure regulator in a vapor compression distillation system.

In still another embodiment of the invention, a backpressure regulator further includes a vessel having an orifice connected to the pressurized conduit, wherein the port is an opening of the orifice and the arm is hinged to the pressure vessel. The vessel may also include a drain orifice.

Brief Description of the Drawings

The foregoing features of the invention will be more readily understood by reference to the following detailed description, taken with reference to the accompanying drawings, in which:

Fig. 1A is side view of a backpressure regulator in accord with an embodiment of the invention;

Fig. 1B is a diagonal view of the backpressure regulator shown in Fig. 1A;

Fig. 2A is a side view of a backpressure regulator with a vertically positioned port in accord with an embodiment of the invention;

Fig. 2B is a diagonal view of the backpressure regulator shown in Fig. 2A;

Fig. 3 is a schematic of a backpressure regulator implemented into a process, consistent with an embodiment of the invention;

Fig. 4A is a diagonal view of a backpressure regulator in accord with an embodiment of the invention;

Fig. 4B shows a close-up view of section **C** of Fig. 4A, depicting a notch in the port of the backpressure regulator;

Fig. 5A is a cutaway side view of a backpressure regulator consistent with an embodiment of the invention; and

Fig. 5B is a close up view of section **E** of Fig. 5A, depicting a small opening in an orifice of the backpressure regulator.

Detailed Description of Specific Embodiments

Figs. 1A and 1B depict views a backpressure regulator consistent with an embodiment of the invention. The backpressure regulator **100** has a vessel **150** containing an orifice **110**. One side of the orifice is connected to a pressurized conduit of a system (e.g., the outlet of a compressor in a vapor compression distillation system) which may be exposed to the fluctuating elevated pressure. The other side of the orifice terminates in a port **170**. The port **170** is covered by a movable stop **130**, in the shape of a ball. The stop **130** is retained to an arm **120** by means of a retainer **160** at a fixed distance from a pivot pin **140**. The arm **120** is attached by a hinge via the pivot pin **140** to a point with a fixed relation to the orifice port **170**. The arm **120** includes a counter mass **180** suspended from the arm that is movable along an axis **190** such that the distance between the counter mass **180** and the pivot pin **140** may be varied. In the embodiment shown in Fig. 1A, the axial direction of the orifice **110** is perpendicular to the direction of the gravitational vector **195**. The backpressure regulator may also include a housing, which prevents foreign matter from entering the regulator and interfering with the function of the internal components.

In operating the embodiment shown in Figs. 1A and 1B, the arm **120** maintains a horizontal position with respect to the direction of gravity **195** when the pressure in the pressurized conduit is below a given set point; this arm position, in this embodiment, is known as the closed position, and corresponds to the stop **130** covering the port **170**. When the pressure in the conduit exceeds the set point, a force acts on the stop **130**, which results in a torque acting around the pivot pin **140**. The torque acts to rotate the arm **120** around the pivot pin **140** in a counter-clockwise direction, causing the arm to move away from its closed position and exposing the port **170**, which allows fluids (e.g.s, gases, liquids, and combinations of both) to escape from the orifice **110**. When the pressure in the conduit is relieved below the set point, the force of gas is no longer sufficient to keep the arm **120** away from its closed position; thus, the arm **120** returns to the closed position, and the stop **130** covers the port **170**.

In the embodiment of Figs. 1A and 1B, the arm **120** acts as a lever in creating adjustable moments and serves to multiply the force applied by the counter mass **180** through the stop **130** to the port **170**. This force multiplication reduces the weight needed to close the orifice **110** as opposed to a design where the stop **130** alone acts vertically on top of the

orifice **110**, as in a pressure cooker. Thus a large port size, to promote expedited venting from a pressurized conduit, may be covered by a relatively lightweight, large-sized stop, the counter mass acting to adjust the desired set point; less design effort may be expended in choosing specific port sizes and stop properties. The addition of an axis **190** for adjusting the position of the counter mass **180**, in the present embodiment, allows for changes in the multiplier ratio. As the counter mass **180** is moved to a position closer to the pivot pin **140**, the multiplier ratio is reduced, creating a lower closing force. If the counter mass **180** is moved farther from the pivot pin **140**, the multiplier ratio is increased, hence increasing the closing force. Therefore, the position of the counter mass **180** effectively acts to adjust the set point of the backpressure regulator.

Adjustment of the backpressure regulator set point may be useful, when the backpressure regulator is utilized in systems at higher altitudes. When the atmospheric pressure is lower, the system operating pressure is commensurately lower. As a result, the temperature of the distillation apparatus is lowered, which may adversely affect system performance. As well, such adjustment allows one to identify set points for the backpressure regulator that are desired by the end user. The use of a counter mass to apply the closing force may also lower cost of the backpressure regulator and reduce component fatigue. In a particular embodiment of the invention, the adjustable counter mass is designed to allow a range of set points with a lowest set point substantially less than or equal to 10 psig. and a highest set point substantially greater than or equal to 17 psig. Thus embodiments of the invention allow for precise system pressure regulation, unlike devices which act simply as safety relief valves.

In another embodiment of the invention shown in Figs. 2A and 2B, the orifice **210** is configured such that the port **270** is oriented vertically with respect to the direction of gravity **295**. Thus other embodiments of the invention may accommodate any orifice orientation while maintaining the use of an adjustable counter mass.

In an embodiment of the invention shown in Figs. 1A, 1B, and 3, the vessel **150** includes a drain orifice **115**. Since the backpressure regulator **100** may operate within a bounded region **310** of a large system **320**, the drain orifice **115** acts as a pathway to release fluids that are purged from the pressurized conduit **340** through orifice **110** into the bounded region **310**. The drain orifice **115** may connect the bounded region **310** to another area of the

larger system, or to the external environment **330**. In addition, the build-up of gases in the bounded region **310** may result in condensation of such gases. Also, gases purged through the orifice **110** may be entrained with droplets of liquid that may accumulate in the bounded region **310**. Thus the drain orifice **115** may also be used to purge any build up of condensables that accumulate in the bounded region **310**; the condensables may also be released from the bounded region using a separate orifice **350**.

The backpressure regulator may be configured to allow a small leakage rate below the set point in order to purge the build up of volatile gases that act to insulate heat exchange and suppress boiling in a system; the regulator is designed, however, to allow pressure to build in the pressurized conduit despite this small leakage. In an embodiment of the invention, release of volatile components from a pressurized conduit, below the set point of the backpressure regulator, may also be achieved through a specifically-designed leak vent while the arm of the backpressure regulator is in the closed position. The leak vent is configured to allow a certain leakage rate from the port or the orifice while the pressure in the conduit is below the set point. Such leak vent may be designed by a variety of means known to those skilled in the art. Non-limiting examples include specific positioning of the stop and port to allow a small opening while the arm is in the closed position; designing the port such that a notch in the port results in a small opening when stop covers the port; specifying a particular rigid, non-compliant seal configuration between the stop and port when the arm is in the closed position; and configuring the orifice leading to the port to have a small opening to allow leakage of fluids.

In a particular embodiment of the invention directed toward the leakage of volatiles below the set point of the backpressure regulator, the port **410** has a notch **420** as shown in Fig. 4A and the close-up of region **C** of Fig. 4A depicted in Fig. 4B. Thus, when a stop is in contact with the port **410**, and the arm of the backpressure regulator is in the closed position, a leak vent is present at the position of the notch **420** that allows a leakage of fluid. In another particular embodiment of the invention, orifice **510** has a small opening **520**, as depicted in Fig. 5A and blow up of region **E** of Fig. 5A depicted in Fig. 5B. The opening **520** is configured such that a leak vent is created when the stop covers the port **510** since fluids may leak through the opening **520**.

Various features of a backpressure regulator consistent with embodiments of the invention may be altered or modified. For example, stops to be used with backpressure regulators may have any shape, size, or mass consistent with desired operating conditions, such stops need not be ball-shaped as shown in some embodiments of the invention discussed herein. As well, stops of different weight but similar sizes may be utilized with the retainer to alter the set point of the regulator. Similarly, counter masses of different sizes, shapes and masses may be utilized with embodiments of the invention as long as they are accommodated by the axis and arm configurations (compare **180** in Figs. 1A and 1B with **280** in Figs. 2A and 2B); such counter masses may be attached and oriented relative to the arm by any of a variety of techniques apparent to those skilled in the art. The pivot pin placement need not be positioned as shown in Figs. 1 and 2, but may be positioned wherever advantageous to provide the mechanical advantage required to achieve a particular pressure set point.

Embodiments of the invention may optionally utilize the drain orifice feature described earlier. Also, embodiments of the invention may not utilize the counter mass force adjustment feature, relying on the specific properties of a stop to provide the set point for the backpressure regulator.

Other embodiments of the invention may not utilize a vessel, but rely on orifices that are intrinsically part of the system. In such instances, the backpressure regulator arm may be directly attached to a portion of the system such that the arm, stop, and counter mass are appropriately oriented for the operation of the regulator.

It is understood that the present invention is not to be limited by the embodiments of the invention described herein. Indeed, those skilled in the art will readily understand that various modifications and embodiments of the invention may be made and practiced without departing from the scope of the invention.